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ABSTRACT

This Likert-type attitude questionnaire was developed to evaluate the attitudes of secondary school students toward science. The questionnaire contains 5 subscales each comprising 12 item (6 positive, 6 negative). The subscales relate to the following 5 attitude objectives: interrelationship between sciences, relationship of science to other subjects, social and economic implications, interest, and objectivity. The instrument is accompanied by a paper describing the way in which the attitude measures were chosen and a pilot study of the instrument, including results from various statistical analyses of the pilot study. Among the statistical results presented are the Pearson product-moment correlation coefficients for the test-retest reliabilities for each subscale and the full scale, and a "t" test for correlated means carried out on the mean scores for each group of students on the test and retest. (MLH)

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ATTITUDES TO SCIENCE

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1971

ED120019

SE 020 530

ATTITUDES TO SCIENCE

This is not a test. Your teachers will not see these papers. We just want to know how you feel about SCIENCE. There are no right or wrong answers.

The questionnaire contains a large number of statements. We want to know whether you agree with them or not. On this page there are some practice statements. Place this booklet slightly over your answer sheet so that the spaces for the answers are exactly opposite the statements. You will see there is a number 4 in the answer box opposite statement A. The answer "Agree" has been chosen here.

If your answer was "Agree" you would also write a 4.

If you felt more strongly than that you would write 5 for "Strongly Agree".

If you disagreed you would write 2 or 1 for "Disagree" or "Strongly Disagree".

If you did not know how you felt or if you were undecided you would write 3 for "Don't know".

Now try the other practice statements yourself:

PLEASE DO NOT WRITE ON THIS PAPER

A. Mathematics is an interesting subject.

- 5 Strongly Agree
- 4 Agree
- 3 Don't know
- 2 Disagree
- 1 Strongly Disagree

B. Girls do not need to learn mathematics.

- 5 Strongly Agree
- 4 Agree
- 3 Don't know
- 2 Disagree
- 1 Strongly Disagree

C. Many people find mathematics difficult.

- 5 Strongly Agree
- 4 Agree
- 3 Don't know
- 2 Disagree
- 1 Strongly Disagree

D. Mathematics is no use to me at home.

- 5 Strongly Agree
- 4 Agree
- 3 Don't know
- 2 Disagree
- 1 Strongly Disagree

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

In the booklet you will find 60 statements. Read each statement carefully, decide which answer best describes how you feel about the statement and put the number of the answer in the correct box. Please choose only one answer for each statement. Rub out or cross out clearly any answer you wish to change. WORK AS QUICKLY AS YOU CAN. DO NOT MISS OUT ANY OF THE STATEMENTS.

- | | |
|--|--|
| 1. "Scientists should criticize each others' work". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 2. "Chemical reactions are of interest only to those who learn chemistry". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 3. "A knowledge of acids and alkalis is useful in cooking". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 4. "I would enjoy doing scientific work when I leave school". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 5. "Mathematics is a great help to science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 6. "If the teacher and I do the same experiment but get different results, the teacher's result is the right one". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 7. "Science is very useful to several of my other school subjects". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 8. "Biologists studying plants and animals do not need to know anything about electricity". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 9. "Science is of no use to anyone who is going to be a physical education teacher". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 10. "If a famous scientist and an unknown scientist disagree we accept the opinion of the famous scientist". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

- | | |
|---|--|
| 11. "Scientists do nothing for me". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 12. "Geography provides examples of things we learn about in science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 13. "Science teachers know the scientific truths". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 14. "Only people who are going to do scientific work should have to learn science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 15. "Science does not help someone to learn geography". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 16. "A good scientific theory does not supply the final answer to scientific questions". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 17. "Biologists, chemists and physicists work in quite different ways from each other". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 18. "Science is only for brainy folk". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 19. "If you were interested in studying animals' eyes you would need to know some physics". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 20. "Everyone can help to prevent science endangering our lives". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

- | | |
|---|--|
| 21. "Space research is no use to ordinary people". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 22. "Energy is important to the study of biology and chemistry as well as physics". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 23. "Science would be very difficult if we had no mathematics". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 24. "I am not interested in science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 25. "There are very clear boundaries separating physics, chemistry and biology". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 26. "Science is so difficult that only highly trained scientists can understand it". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 27. "To study pond life you have to work like a physicist, chemist and biologist all combined". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 28. "Experiments which give answers that disagree with what the teacher expects are useful". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 29. "If a good scientist says that a theory is true all other scientists will believe him". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 30. "I enjoy science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

- | | |
|--|--|
| 31. "I would not like to be a scientist". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 32. "To understand the human body a biologist must know a lot of chemistry". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 33. "I would rather be a famous scientist than the Prime Minister". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 34. "Lots of information we get from science now will be changed in the future". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 35. "Scientists are boring people". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 36. "I wish we had more science in school". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 37. "Science does not help you to learn anything about music". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 38. "Science needs the understanding and support of ordinary people". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 39. "Science is boring for me". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 40. "Scientific theories supply the true answers to scientific questions". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

- | | |
|--|--|
| 41. "I hate science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 42. "Science lessons are no use to an athlete". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 43. "Science does not help us to understand weather and climate that we learn about in Geography". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 44. "Science does not affect my daily life at home". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 45. "Science should be left to those who are scientists or who are going to be scientists". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 46. "Science teaches us not to believe everything we are told". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 47. "Scientists are very interesting people". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 48. "A useful scientific theory may not be entirely correct". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 49. "New discoveries in science are important to everyone". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 50. "Physics, chemistry and biology are all part of the same subject". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

- | | |
|---|--|
| 51. "I make use of science every day". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 52. "Good scientists know the true laws of science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 53. "People who plan school dinners need to know a lot of science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 54. "Biology, chemistry and physics are all called science but are not connected in any other way". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 55. "Chemistry is no help to physics". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 56. "Science can help man to live more comfortably". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 57. "Science is one of my favourite subjects". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 58. "Everyone in the modern world needs to learn science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 59. "Chemical energy is important to physics". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |
| 60. "An artist has no need to learn science". | 5 Strongly Agree
4 Agree
3 Don't know
2 Disagree
1 Strongly Disagree |

UNIVERSITY OF STIRLING, DEPARTMENT OF EDUCATION

'Attitude to Science' Scale-Scoring Procedure

(Developed for comparison of group mean scores of S1 and S2 pupils on scales corresponding to five attitude objectives laid down for this age-group in Curriculum Paper 7, 1969, HMSO Edinburgh)

There are five subscales corresponding to each of the attitude objectives laid down in Curriculum Paper Seven. Each subscale consists of five 'positive' and five 'negative' items. The pupil's score on each subscale is simply the difference between his 'positive' and 'negative' totals. The following key indicates the item numbers corresponding to each subscale:

<u>Subscale</u>	<u>'Positive' item numbers</u>	<u>'Negative' item numbers</u>
1. 'inter-relationship of different science disciplines'	19, 22, 27, 32, 50, 59	2, 8, 17, 25, 54, 55
2. 'relationship of science to other school disciplines'	3, 5, 7, 12, 23, 53	9, 15, 37, 42, 43, 60
3. 'Social & economic implication of science for community'	20, 38, 49, 51, 56, 58	11, 14, 21, 26, 44, 45
4. 'interest and enjoyment'	4, 30, 33, 36, 47, 57	18, 24, 31, 35, 39, 41
5. 'objectivity'	1, 16, 28, 34, 46, 48	6, 10, 13, 29, 40, 52

Sally Brown.

Practice
Statements

No. Answer

A

B

C

D

PAGE 1		PAGE 2		PAGE 3		PAGE 4		PAGE 5		PAGE 6	
No.	Answer	No.	Answer	No.	Answer	No.	Answer	No.	Answer	No.	Answer
1		11		21		31		41		51	
2		12		22		32		42		52	
3		13		23		33		43		53	
4		14		24		34		44		54	
5		15		25		35		45		55	
6		16		26		36		46		56	
7		17		27		37		47		57	
8		18		28		38		48		58	
9		19		29		39		49		59	
10		20		30		40		50		60	

ATTITUDES TO SCIENCE : ANSWER SHEET

Today's date:

Name of your School:

Your full name:

Girl

Boy

Date of your birth: 19 . .

Leave Blank

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Construction of the Attitude Scales

The purpose of this empirical study was to evaluate the achievement of each of five attitude objectives. There was no reason to believe that these objectives *necessarily* corresponded to distinctive dimensions of attitudes possessed by pupils (the extent to which such correspondence exists will be explored in Chapter 6). Consequently it was felt that factor analytic methods (such as those used by Omerod 1971 or Skurnik and Jeffs 1971) for attitude scale development would be inappropriate. It was decided that five separate subscales should be drawn up and combined to form a single questionnaire. The objectives range from those which emphasise intellectual (highly cognitive) attitudes to those which emphasise emotional attitudes but it was expected that there would be substantial correlations between some subscale scores.

Position statements

Meetings were held with two members of the Working Party that wrote Curriculum Paper 7 in order that they might expand and define the objectives. The outcome of these meetings was a list of *position statements* that, the two Working Party members agreed, reflected their intentions for the objectives. Two statements were constructed for each objective: an 'A' statement identifying an appropriate 'favourable' attitude, and a 'B' statement identifying an appropriate 'unfavourable' attitude.

The first attitude objective (*awareness of the inter-relationship of the different disciplines of science*), it was revealed, was included in the Paper in order to allay the fears of those who felt that there was some danger of pupils reaching the end of S2 with little idea of what constituted

the separate science disciplines that make up the S3 course. For this reason certain sections of the syllabus had been deliberately chosen as separate physics, chemistry and biology components in the hope that pupils would become aware of the separate subjects but at the same time would be able to look back to the earlier sections for the inter-relationships. The position statements developed for this objective were:

'A: It is sometimes convenient for us to divide science into three sections: biology, chemistry, and physics. Although each of these three sections stands alone at some points, there are many overlapping concepts and techniques which link two or all three.'

'B: Physics, chemistry, and biology are separate, independent subjects.'

For the second attitude objective, *awareness of the relationship of science to other aspects of the curriculum*, the following position statements were put forward:

'A: I can see that other subjects such as geography, art, music, homecraft, physical education, and agriculture depend in many ways on science for their development. Science in turn depends on mathematics.'

'B: Science is of little use to any other subjects. Artists, musicians, geographers, P.E. teachers, farmers, and homecraft teachers have no need of it. Science can carry on quite successfully without mathematics.'

The Working Party had been anxious that this course would not attempt to coerce pupils into regarding science as making only 'good' contributions to society. They felt strongly that the pupil must be given the opportunity to recognize and examine the 'bad' aspects as well. The third attitude objective, *awareness of the contribution of science to the social and economic life of the community*, was characterized by:

'A: Our lives are affected both favourably and unfavourably by progress in science. Everyone should be made aware of the nature of science and what it attempts to do.'

'B: Understanding of science by the general public would contribute nothing to the community nor to the advancement of science. Science and the community can operate independently of each other.'

The objective *Interest and enjoyment in science* led to:

'A: Science is an interesting, rewarding and enjoyable subject. I would enjoy doing scientific work.'

'B: Science is dull and uninteresting. It is only suitable for "brainy folk". I would not enjoy doing scientific work.'

(The members of the Working Party used the word 'swots' rather than 'brainy folk'.)

For the final attitude objective (*an objectivity in observation and in assessing observations*) the following position statements were developed:

'A: A good scientist depends on observations of phenomena that are empirically verifiable, reproducible and free from the experimenter's idiosyncracies. He is intellectually honest and is ready to alter his position on the basis of further evidence.'

'B: A good scientist offers true explanations of observable phenomena. He accepts the results of the other good scientists and always takes their side.'

Choice of attitude measure

It was decided (see Chapters 7 and 8) that the empirical study of attitudes related to the Curriculum Paper 7 objectives should involve a very large

number of pupils (3000+). In view of this, direct observation of behaviour of the pupils would have been impractical and pencil and paper measures of attitudes appeared the obvious choice (in any event behaviour has many determinants other than one specific attitude and so is unlikely to be a reliable indication of a particular attitude - see Chapter 2).

There were a number of qualities that it was necessary, or at least desirable, for the attitude measure to have:

- 1) It must be suitable for administration to large numbers of pupils.
- 2) The response procedures, vocabulary and meanings of statements must be understood by young pupils (12 years old) of a wide range of abilities.
- 3) The response procedures must allow for 'don't know/undecided' attitudes since the instrument would be administered to pupils on entry to school before they have experienced any secondary school science.
- 4) The instrument should be constructed by well established and documented techniques, and the construction should not be too time consuming.
- 5) The instrument should be reliable (internal consistency and stability).
- 6) The instrument should be valid *i.e.* measures what it is supposed to measure.
- 7) It should be composed of unidimensional components relating to each of the five attitude objectives insofar as the interdependence among those objectives permits this.

- 8) The instrument should aim to provide an interval scale on which attitudes may be measured, or, if possible a ratio scale with a zero point related to a neutral attitude.
- 9) The scale should have high reproducibility *i.e.* two identical scores should not be obtainable in a number of different ways (reproducibility of scores on a scale is closely related to the unidimensionality of the items of that scale, Shaw and Wright 1967, page 25).

No single instrument is completely satisfactory on all these criteria. The various methods have concentrated on different scale requirements. In comparison with, say, measures of cognitive achievement they are crude.

'Their measurements are relative, and the proper use of an attitude scale is to allow comparisons of the attitudes of different groups or of individuals compared with that of groups, or to assess the effect on attitudes of changes in, say, a school curriculum' (Nisbet and Entwistle, 1970, page 126).

and 'Such scales cannot, by themselves, be expected to provide us with subtle, insights in an individual case' (Oppenheim, 1966, page 121).

The decision was made to use a summated-rating or Likert-type scale (Likert 1932). This is probably the most widely used type of scale in behavioural research and particularly in educational research.

Likert scales are less laborious to construct than other commonly used scales such as the equal-appearing intervals of Thurstone (1929) scales, or the scalogram-analysis of Guttman (1950) scales.

Collection of items

Items for the scales were collected from audio tape recordings made during conversations with small groups of first and second year pupils from comprehensive schools. The items consisted of (i) statements made by these pupils; (ii) statements constructed using the vocabulary of the pupils. One hundred and fifty items together with the 'position statements' were submitted to a panel of 8 judges (1 educational psychologist, 4 HMI's, 2 science teachers, 1 university science education tutor) and each judge was asked to decide for each item whether it indicated a particular favourable (or positive) attitude, an unfavourable (or negative) attitude, both favourable and unfavourable attitudes, or neither favourable nor unfavourable. A final selection of 100 items, on which the judges were in agreement, was made. (Instruction for judgment of items will be found in Appendix A.)

These 100 items were made up of 10 positive and 10 negative items for each of the five subscales. The items were randomized within a single questionnaire.

This procedure follows that of Moore and Sutman (1970) and the assumption is made that:

'if a respondent agrees with the attitude statement [item], that agreement could be taken as evidence that he assumes the position statement for which the attitude statement was written'.

Pilot sample

Three groups of pupils were used in order to cover the complete age range over which this scale will be used. Seventy-five pupils from two schools formed the final year primary group, 125 pupils from two comprehensive schools formed the first year secondary group, 123 pupils from the same comprehensive schools formed the second year secondary group. One of the comprehensive schools followed the Integrated Science course for the first two years, the other followed separate biology, physics and chemistry courses. In each case mixed ability groups were used but children unable to read were excluded.

Procedure

All pupils were given the attitude scale once and those from one comprehensive school (64 first year, 63 second year) and one primary school (49 pupils) were given it again 4 days later. During this time they had no science lessons. In addition to this the AH4 group test of general intelligence was administered to the pupils of one of the comprehensive schools, together with three tests of 'divergency'. (The purposes of, and results from, the tests of divergency will be discussed in Chapter 8.)

Statistical Analysis

An item analysis of the 100 item scale was carried out using the following procedure; (i) identification of the top 25% and the lowest 25% of pupils' scores for each subscale total; (ii) computation of mean score for each of these groups on each item relating to this subscale; (iii) application of a 't' test to the difference between the high mean and low mean; (iv) selection of items with the highest 't' value (see Edwards 1957, page 152). The 't' values for the items accepted were all significant at a minimal 0.01 level. The final scale consisted of 60 items making up 5 subscales, each subscale containing 6 'positive' and 6 'negative' items relating to one of the attitude objectives. All attitude scores from this point on refer to this 60 item scale. (The 60 item questionnaire will be found in Appendix A.)

Pearson product-moment correlation coefficients for the test-retest reliabilities for each subscale and the full scale were determined for primary pupils, first year secondary, and second year secondary pupils. These coefficients were found to be satisfactory for all three groups of pupils provided the scale is to be used for comparing groups of pupils rather than assessing attitudes of individuals ($r = 0.93, 0.86, 0.92$, for total scores, lowest value of $r = 0.55$ for subscale 1 for primary pupils, see Table 5.1). 't' tests for correlated means were carried out on the mean scores for each of the groups of pupils on the test and retest. No

hereafter scales
used with
secondary
school pupils
only.

TABLE 5.1 TEST/RETEST RELIABILITY COEFFICIENTS : ATTITUDE SUBTOTALS AND TOTAL

	Subtotal 1	Subtotal 2	Subtotal 3	Subtotal 4	Subtotal 5	Total
Primary	0.55	0.86	0.87	0.91	0.78	0.93
S1	0.72	0.83	0.74	0.88	0.75	0.86
S2	0.69	0.81	0.81	0.91	0.78	0.92

Primary n = 50
S1 n = 64
S2 n = 62

All r's
significant
.001 level

TOTAL ATTITUDE SCORE : DIFFERENCES BETWEEN TEST AND RETEST MEAN SCORES

Primary	S1	S2
20.98	30.01	29.53
23.53	18.57	23.33
24.38	32.35	33.14
29.33	20.41	23.46
0.64	0.67	0.85
N.S.	N.S.	N.S.

mean score test

s.d.

mean score re-test

s.d.

t value

significant differences were found (see Table 5.1). The internal consistency or homogeneity of items for each of the subscales was determined from the split half method giving values of 0.72, 0.83, 0.74, 0.93 and 0.62 for Spearman-Brown reliability coefficients.

A correlation matrix (Table 5.2) showing inter-relationships between subscales and the full scale was computed. Correlation coefficients for AH4 scores and attitude subscale scores for the smaller group of secondary school pupils are also shown in Table 5.2. Two-way analyses of variance on the scores of the secondary school pupils were carried out for each of the subscales to investigate the main and interaction effects of sex and type of science course, and sex and age. Those giving significant results are reported in Table 5.3. 't' tests were then carried out to investigate differences between boys' and girls' mean scores for the three age groups and for the 'integrated science' and 'separate science' secondary groups (Table 5.4). These differences between the mean scores of the various groups of pupils on each of the subscales were examined with a view to identification of hypotheses that seem to be worth exploring in the larger main study.

Discussion of results

An interesting feature of the test and retest scores that emerged was the consistent trend for all groups of pupils to show an increase in mean score (63% of the individual scores increased). Other evaluation projects (Wynn and Bledsoe 1967, Science 5/13 1971, and Nuffield Secondary Science - Evaluation, Alexander 1972) have found that scores on attitude measures have dropped for post-tests. This has been explained in terms of negative

TABLE 5.2 CORRELATION COEFFICIENTS BETWEEN ATTITUDES SUBSCALE SCORES AND A.H.4 SCORES
(Figures in brackets give level of significance)

	Subtotal 1	Subtotal 2	Subtotal 3	Subtotal 4	Subtotal 5
	"inter-relationship between sciences"	"relationship of of science to other subjects"	"social and economic implications"	"interest"	"objectivity"
All pupils n = 23					
Subtotal 2	0.51 (0.001)				
Subtotal 3	0.50 (0.001)	0.54 (0.001)			
Subtotal 4	0.41 (0.001)	0.44 (0.001)	0.62 (0.001)		
Subtotal 5	0.32 (0.001)	0.27 (0.001)	0.37 (0.001)	0.07 (N.S.)	
Total:	0.71 (0.001)	0.75 (0.001)	0.85 (0.001)	0.80 (0.001)	0.46 (0.001)
First year pupils n = 64	0.44 (0.01)	0.24 (N.S.)	0.05 (N.S.)	0.05 (N.S.)	0.17 (N.S.)
Second year pupils n = 63	0.13 (N.S.)	0.22 (N.S.)	0.43 (0.01)	0.15 (N.S.)	0.30 (0.05)

TABLE 5.3 2-WAY ANALYSIS OF VARIANCE

	Source	Variance	df	Mean Sq.	F Ratio	Significance Level
Subtotal 2: "Relationship with other school disciplines"	Between Courses	460.7	1	460.7	12.15	0.001
	Between Years	105.8	1	105.8	2.79	N.S.
	Interaction Year/Course	10.9	1	10.9	0.29	N.S.
	Residual (within)	9250.8	244	37.91		
	Total:	9828.2	247			
Subtotal 3: "Social and economic implications"	Between Sex	290	1	290	8.19	0.01
	Between Course	50	1	50	1.41	N.S.
	Interaction Sex/Course	210	1	210	5.93	0.025
	Residual (within)	8640	244	35.4		
	Total:	9190	247			
Subtotal 4: "Interest"	Between Sex	1158.7	1	1158.7	11.58	0.001
	Between Year	271.3	1	271.3	2.71	N.S.
	Interaction Sex/Year	350	1	350	3.50	N.S.
	Residual (within)	24414	244	100.01		
	Total:	26194	247			
Subtotal 5: "Objectivity of observation and assessing observations"	Between Sex	50	1	50	2.19	N.S.
	Between Course	220	1	220	9.65	0.01
	Interaction Sex/Course	20	1	20	0.9	N.S.
	Residual (within)	5557	244	22.8		
	Total:	5860	247			

TABLE 5.4 't' VALUES FOR DIFFERENCES BETWEEN MEAN SCORE OF PUPILS GROUPED BY SEX, YEAR AND TYPE OF SCIENCE COURSE
(Figures in brackets show significance level)

Group	Sub-groups for 't' test	Subtotal 1	Subtotal 2	Subtotal 3	Subtotal 4	Subtotal 5	Total
Primary	Boys & girls (b) (g)	2.45 (0.02) b > g	3.75 (0.001) b > g	1.63 (NS)	3.71 (0.001) b > g	0.64 (NS)	3.52 (0.01) b > g
1st year secondary	Boys and Girls	0.06 (NS)	1.49 (NS)	0.83 (NS)	1.32 (NS)	2.43 (0.02) b > g	1.78 (NS)
2nd year secondary	Boys & Girls	0.03 (NS)	1.36 (NS)	2.79 (0.01) b > g	3.25 (0.002) b > g	0.36 (NS)	2.46 (0.02) b > g
'Separate subject'	Boys & Girls	0.61 (NS)	1.52 (NS)	0.10 (NS)	1.20 (NS)	2.29 (0.05) b > g	1.43 (NS)
'Integrated Science'	Boys & Girls	0.58 (NS)	1.52 (NS)	3.64 (0.001) b > g	3.49 (0.001) b > g	0.12 (NS)	2.54 (0.02) b > g
1st year secondary n = 125	'Separate' (S) 'Integrated' (I)	1.52 (NS)	2.68 (0.01) I > S	0.02 (NS)	2.52 (0.02) S > I	2.21 (0.05) I > S	0.11 (NS)
2nd year secondary n = 123	'Separate' and 'Integrated'	1.57 (NS)	1.43 (NS)	1.49 (NS)	1.26 (NS)	1.57 (0.05) I > S	1.37 (NS)
Boys 1st & 2nd year n = 127	'Separate' and 'Integrated'	0.90 (NS)	2.09 (0.05) I > S	2.66 (0.01) I > S	0.82 (NS)	0.91 (NS)	1.58 (NS)
Girls 1st & 2nd year n = 119	'Separate' and 'Integrated'	2.35 (0.05) S > I	2.08 (0.05) I > S	1.04 (NS)	1.57 (NS)	3.54 (0.001) I > S	0.16 (NS)

reactions to the test itself (Science 5/13 1971), *e.g.* boredom at 'having to do the thing again', rather than a real unfavourable change in attitude towards science. It seems likely that this type of effect would be most apparent if the time between test and retest was short. Yet here 'no science' results in an apparent increase in score over a very short period of time, while other 'science courses' result in apparent decreases in score over longer periods of time.

The inter-subscale correlations (see Table 5.2) were all positive and significant at the 0.001 level with the exception of that between scores on subscale 4 (interest) and subscale 5 (objectivity). For this pair the correlation was not significant. It is suggested that these two may represent the affective and cognitive extremes of the attitudes being investigated. Insofar as the items of the scales reflect the position statements, subscale 5 demands a substantially higher level of cognitive activity than does the predominantly 'emotional' subscale 4. Several studies (*e.g.* Neidt and Hedlund 1969 and Rothman 1969) have pointed to cases in which gains in the cognitive and affective domains are not significantly correlated.

In studies of the relationship of *cognitive* achievement in science to intelligence for older (and often more able) pupils than our sample, positive relationships have been reported (Brandwein 1951, Anderson, Page and Smith 1958, Butcher, Ainsworth and Nesbitt 1963, Hudson 1966 and Meister 1966). On the other hand studies of younger pupils with a wider range of intelligence (Daniels 1956, Meyer 1961, Cline, Richard and Abe 1964, Tyler 1964, Winder 1966, Wynn and Bledsoe 1967) have indicated zero or negative relationships between intelligence and science bias this being particularly marked if the *affective* measure of 'interest in science' is used as the criterion for

science bias. This is supported by the non-significant relationship between AH4 scores and the 'interest' scores of subscale 4. The suggestion that cognitive science achievement and general intelligence are related for *older* pupils is supported by the zero relationship between AH4 and subscales 3 and 5 for first year pupils, and the positive significant relationship for second year pupils.

The correlations between AH4 and the other attitude scores were low (see Table 5.2). There was a relationship ($p < 0.01$) between 'awareness of the inter-relationship of the different disciplines of science' and AH4 for first year but not for second year pupils. It is suggested that in the short time that the first year pupils had been exposed to science it would be those of higher intelligence (as measured by AH4) who would have been able to sort out what the 'different disciplines of science' were. By the second year this may well have been achieved by most pupils so correlation with intelligence could be expected to disappear.

From Table 5.4 it is seen that for 'awareness of the inter-relationship of the different disciplines of science' (subscale 1) there was no significant difference between boys' mean scores and girls' mean scores except among the primary school pupils, the boys' mean score being higher. There was no significant difference between mean scores of the boys following the 'integrated science' course and those of boys following 'separate science' subjects. In the case of girls, however, the 'separate science' course group scored higher.

It has been suggested (Roe 1963) that a science sex-difference is culturally determined long before the pupils arrive at secondary school. The primary

school and home may provide activities and reading material for boys that will reinforce a science orientation, and at the very least provide familiarity with words such as 'chemistry', 'physics' and 'biology'. The girls are less likely to have reinforcement in this area and so may arrive at secondary school quite unaware that there are 'different disciplines of science' let alone any inter-relationship. Once at secondary school it is possible that those directed to biology, chemistry and physics classes in a 'separate subject' course will attain this awareness sooner than those in an 'integrated science' course.

Subscale 2 ('awareness of the relationship of science to other aspects of the curriculum') again showed differences between the sexes at the primary school level only, the boys having the higher mean score. Both boys and girls following the Integrated Science course had mean scores significantly ($p < 0.001$) higher than those of pupils following separate subject courses, the effect being most pronounced in first year secondary pupils. Table 5.3 shows the significant mean effect of course type ($p < 0.001$).

Tables 5.3 and 5.4 show that at an overall 1% level boys' mean scores were significantly higher than girls' on subscale 3 ('awareness of the social and economic implications of science'). The highest mean scores here were from boys following the 'integrated science' course. Their mean scores were significantly higher than boys following the 'separate subjects' course but there were no significant differences between the two groups of girls.

'Interest and enjoyment' (subscale 4) appeared as a male characteristic since primary boys, S2 boys and 'integrated science' boys had significantly higher mean scores than the corresponding groups of girls. The 'separate science' pupils were significantly higher on interest mean scores than the

'integrated science' pupils in S1 but there was no significant difference in S2. In general girls' mean scores fell as from first to second year. This sex difference 'which seems to be characteristic of our culture' (Wynn and Bledsoe 1967) is in agreement with other studies of similar groups in the United Kingdom and the United States (this will be discussed further in Chapter 7).

The significant *course* effect ($p < 0.01$) for subscale 5 (see Table 5.3) suggests that Integrated Science may be having a favourable effect on pupils 'objectivity in observation and in assessing observations' (subscale 5) particularly for girls. There was a significant difference between sexes for the 'separate subjects' course (boys scoring higher) but not for the 'integrated science' course. In S1 and S2 the 'integrated science' course pupils' mean scores were significantly higher than the 'separate subject' pupils, this being due to the high scoring of the girls in the Integrated Science group. There was no significant difference between mean scores of boys in each of the two groups.

Field and Cropley (1969) in a study of 178 pupils in the 16 to 18 year age range found that for each sex 'a different pattern of cognitive functioning was...associated with high science achievement'. The major difference between the sexes appeared as a significant positive relationship between originality and science achievement for girls and a corresponding zero relationship for boys. They suggest that in the past school science with over-emphasis on content may have inhibited the development of scientific skills and interest among girls.

It has already been suggested that a relatively high level of cognitive science achievement may be necessary for the attainment of 'objectivity in observation

and assessment of observations'. If this achievement is related to cognitive style then we might expect, according to the Field and Cropley hypothesis, that some teaching strategies would be more suitable for girls than others and they may achieve more in an atmosphere which is not primarily concerned with factual information and where alternative approaches to problems are not inhibited.

Curriculum Paper 7, page 22, stresses that 'In the integrated syllabus which has been prepared for the first two-year cycle, there is much reduced emphasis on the factual content of the syllabus' and that the subject should be 'taught in such a way that creativity...is encouraged and fostered at every possible opportunity'. Our results suggest that in the main study it might be worth exploring the hypothesis that girls achieve attitude objectives that are closely related to cognitive achievement to a greater degree in an Integrated Science course than in a traditional course.

Validity of the attitude subscales

Considerable effort has been made to produce a reliable and valid group of attitude measures. The reliability of each scale has been assessed, but validity is much more difficult to demonstrate and is not a necessary concomitant of reliability.

The process of *content validation* is basically judgmental. The question to be considered is: to what extent is this group of items relevant to, and representative of, the attitude objective under consideration? For this study the definition of the appropriate universe of content was attempted by formulation of 'position statements' by members of the Working Party.

These 'position statements' were used to provide directions to the 'expert' judges about what they were to make judgments on. Finally a pooling of all judgments led to selection of a group of items as the outcome of procedures aiming for a scale that adequately sampled and was representative of the attitude objective.

The *predictive or concurrent validity* of a scale is concerned with relating performance on some other measure (in the future or now) with performance on the scale: An outside criterion measure must be involved and the concern with such validity usually relates to some practical problem (*e.g.* the use of attitude scales to identify potential scientists, or to predict achievement in science examinations, or to act as a substitute for other more complex or cumbersome measures). The major difficulty is the absence of suitable criteria. If we wish to use the scale to predict some aspect of future behaviour we have the problem, discussed in Chapter 2, that the behaviour will have numerous determinants. It might be possible to use the criterion-group approach where, for example, the value of scores on 'Interest and enjoyment in science' might be examined as predictors of pupils who would choose to follow a scientific career. However, this appears an unsatisfactory measure for an objective which, it has been argued in Chapter 2, may be achieved by other behaviour than career choice. If a particular attitude objective has been included for the specific purpose of attaining a particular cognitive end, and if a measure of the appropriate cognitive achievement were available, then the level of predictive validity could be established. There is no evidence for such specific affective-cognitive links among these objectives. In the main study (Chapters 11, 12 and 13), the value of attitude measures taken on entry to secondary school as predictors of attitudes and of achievement in science in S2, and the

relationships between attitude measures and teachers ratings of pupils, will be examined.

The concept of *construct validity* (Cronbach 1960, page 121) relates scale scores to some *theoretically* defined construct (or attribute) that can explain the variance in those scale scores. In other words the concern is with what it is that is being measured and which leads to individual differences in scale scores, rather than with the scale itself. To establish construct validity it would be necessary to describe constructs that might account for performances on the scale, to predict relationships between these constructs and other variables, and to test these hypotheses empirically. In earlier chapters we have already seen that there is no single generally accepted construct of 'attitude', that the attitude objectives relating to these scales have no substantial theoretical framework from which to derive suitable constructs, and that there is no information on how these objectives relate to any dimensions of attitudes to science that may be displayed by pupils (this question will, however, be considered in Chapter 6). At this time then, it is not possible to carry out a thorough construct validation for these scales.

However, the procedures have, to some extent, led to a description of some curriculum-based constructs (*i.e.* the position statements). These are probably better described as *pragmatic* rather than *theoretical* constructs, but they do permit relationships with other variables to be hypothesized. For example it has been suggested in this chapter and in Chapter 2 that the objectives corresponding to subscales 1, 2, 3 and 5 have strong cognitive components, while that of subscale 4 does not. We would expect that older pupils would have had more opportunities, and be at a more appropriate stage

of development, for the necessary cognitive attainment than would younger pupils. We would therefore hypothesise that pupils would score higher on subscales 1, 2, 3 and 5 (but not on subscale 4) in the second year of secondary school than they would on entry to secondary school. This pilot study has explored the scores of pupils in S1 and S2 in two schools. While the evidence cannot be taken as conclusive (since *different* pupils were assessed in the S1 and S2 groups), Table 5.5 shows that for the two schools only one of the eight hypothesised increases in scores from S1 to S2 has failed to occur (although few of the increases are statistically significant).

The scores on subscale 4 ('Interest and enjoyment in science') appear to decrease from S1 to S2. It has already been suggested (see Chapter 2) that the construct corresponding to this objective is rather broad or global. However, whether the construct is interpreted as a predisposition to follow a career in science, or to opt for science courses in S3, or to tinker with science experiments at home, there is a clear relationship with sex and the hypothesis is that boys will score higher than girls on this scale. Table 5.3 and 5.4 provide firm confirmation of this hypothesis.

The weak relationship between cognitive measures (AH4) and the construct which is strongly affective rather than cognitive (subscale 4), and the stronger (and increasing from S1 to S2) relationship between AH4 and the more strongly cognitive constructs (subscales 3 and 5), have already been pointed to under 'Discussion of Results'.

These observed relationships by no means establish conclusive construct validity for the five subscales. Nevertheless, in terms of the pragmatic

TABLE 5.5

MEAN SCORES FOR S1 AND S2 PUPILS FROM TWO SCHOOLS ON EACH SUBSCALE
(figures in brackets show standard deviations)

School 1			School 2	
S1	S2		S1	S2
5.34	6.73	subscale 1	4.18	5.37
(4.53)	(4.59)		(3.91)	(4.93)
1.75	3.95	subscale 2	4.74	5.63
(6.24)	(6.23)		(6.11)	(6.65)
* 7.66	6.78	subscale 3	7.64	8.48
(5.68)	(5.80)		(5.75)	(6.76)
12.26	7.08	subscale 4	8.00	9.52
(8.06)	(10.41)		(10.57)	(10.89)
3.39	5.03	subscale 5	5.39	6.62
(5.11)	(4.69)		(4.91)	(4.10)

*Subscale 3 for school 1 was the only case for which a hypothesised larger mean score for S2 pupils over S1 pupils did not occur.

constructs we have, these preliminary results provide evidence that is consistent with construct validity.

Summary

A group of 5 attitude scales have been developed and shown to have satisfactory levels of internal consistency and stability. There is reason to assume that the construction procedures have ensured content validity and some degree of construct validity.